SUBJ: SYSTEM REQUIREMENTS STATEMENT FOR THE CENTRAL WEATHER PROCESSOR

1. PURPOSE. This order establishes the system requirements for the Central Weather Processor (CWP) which are consistent with the National Airspace System (NAS).

2. DISTRIBUTION. This order is distributed at director level in the Offices of Airport Planning and Programming, Airport Standards, Aviation Policy and Plans, Budget, and Personnel and Technical Training; to the branch level in the Advanced Automation Program Office, Office of Flight Operations, Air Traffic Operations, Air Traffic Plans and Requirements, Program Engineering and Maintenance, Systems Engineering, and Acquisition and Materiel Services; to the branch level at the FAA Technical Center and the FAA Depot at the Aeronautical Center; and at branch level in the regional Airway Facilities, Logistics, Air Traffic, and Flight Standards Divisions.

3. BACKGROUND. For safe and efficient utilization of the NAS, controllers, pilots, and other personnel directly involved in the air traffic control (ATC) function require access to timely and accurate weather information. Presently, weather support to ATC is provided by aviation meteorologists at the Air Traffic Control Command Center (ATCCC) to support traffic management specialists on a national level and at each Air Route Traffic Control Center (ARTCC) to support ARTCC controllers. Currently, this support utilizes a collection of functionally separate data sources. These generally must be assimilated manually, interpreted manually, and disseminated manually. Automation of this system would result in enhanced dissemination of weather data to users and better utilization of the meteorologist's skills. To provide that improved capability, the Federal Aviation Administration (FAA) is developing the CWP to provide automated weather support to NAS weather users. The CWP will provide national level support at the Traffic Management Facility (TMF) and regional level support at the Area Control Facility (ACF).

4. MISSION NEED. The FAA has a mandate to regulate and monitor the navigable airspace of the United States such that air travel is accomplished in a safe and efficient manner. Of major importance to the safe and efficient conduct of any flight is the complete, accurate, and up-to-date knowledge of weather conditions. The basic mission need is to provide the various NAS users with the real-time and forecast weather information required for safe and efficient use of the NAS. Implicit in this general mission need statement is more specific mission needs which follow:

   a. Ingest weather data from all available sources (e.g., radar, satellite, surface observations, and pilot reports), maintain a complete and current weather data base pertinent to the ARTCC/ACF area, and facilitate the automated dissemination of hazardous and routine weather data to users,

b. Facilitate the display of automatically updated graphic and **alphanumeric** weather data in the controller's work area. These data will provide the clear depiction of hazardous weather areas in the coordinate system used by the **ATC** processing system.

c. Provide Center Weather Service Unit (**CWSU**) meteorologists with a timely and accurate weather data base, as well as the automated tools needed for **display**, analysis, and annotation of these data to support their "nowcast" and short-term forecast responsibilities.

d. Provide rapid dissemination of weather data, including **CWSU** generated products, to other **NAS** users and systems. This will include pilots in **flight** with the implementation of the MODE S data link system. This will allow pilots to obtain, in the cockpit, graphic weather products and will establish the basis for future developments that will allow the collection of pilot reports (**PIREP's**) without handling by ground personnel.

5. EXISTING AND PLANNED CAPABILITIES.

a. Existing Capabilities. In the current system, meteorological support is provided to controllers and specialists from the **CWSU** at each **ARTCC** and from the Central Flow Weather Service Unit (**CFWSU**) at the **ATCCC**. The meteorologist and weather coordinator staffing the **CWSU** operate as a team and have the **following** primary responsibilities:

(1) Meteorologist will provide analysis and interpretation of available weather data to determine actual and near-term forecast weather conditions and to supply a "nowcast" service. Also, will provide dissemination of advisories, forecasts, and analyses to appropriate **ARTCC** positions and other designated facilities either directly or through the weather coordinator.

(2) Weather Coordinator will serve as an interface between the National Weather Service (**NWS**) meteorologist and the facility air traffic staff as required, **primarily** to provide inter/intrafacility dissemination of Significant Meteorological Information (**SIGMET**), Center Weather Advisories (**CWA's**), and urgent **PIREP's** and to provide assistance in the collection and dissemination of other **significant** weather information. To carry out these functions the **CWSU** has access to the following information:

(a) Weather Satellite Imagery. These products are received in facsimile form from the National Environmental Satellite Data and Information Service's Satellite Field Service Station. These image products are produced by the **Geostationary** Operational Environmental Satellite (GOES) system.

(b) Weather Charts. These products are received in facsimile form from the **NWS's** National Meteorological Center (**NMC**).

(c) Alphanumeric Weather Products. These products are received in the **ARTCC** from the Weather Message Switching Center, which in turn receives most of its data from the **NMC**. Until recently, all **CWSU's** and the **CFWSU** received these products on paper via teletypewriter. The teletypewriter equipment is being replaced by a terminal display system known as the Leased Service A System.

(d) <u>Weather Radar Information</u>. This information is received by the
Radar Remote Weather Display System (RRWDS) display equipment recently installed,
This display equipment receives data from associated RRWDS digitizers installed on
the NWS Weather Service Radar (WSR) and on the FAA Air Route Surveillance Radar
(ARSR) and military FPS radars where coverage is not provided by the NWS weather
radars. En route controllers also receive depictions of areas and intensities of
precipitation on the Plan View Display (PVD). This display is generated by the
Weather and Fixed Map Unit (WFMU) of the ARSR. Radial lines drawn from the radar
site depict the location of light to moderate precipitation areas. The alpha char-
acter "H" is displayed to indicate heavy precipitation. En route controllers also
have access to certain routine alphanumeric weather information at each sector's
Computer Readout Device (CRD). Up to four surface observations and six altimeter
settings can be selected and displayed at the "D" sector CRD and "R" position CRD,
respectively. Hazardous weather messages (e.g., SIGMET's, Airmen's Meteorological .
Information [AIRMET's]) are displayed to controllers on paper. Interfacility com-
munications of these products are either verbal or as low priority General Informa-
tion Messages via the en route computer. Terminal facilities rely on the CWSU
from the controlling ARTCC for their hazardous weather information. This informa-
tion is passed as General Information Messages and received on the Flight Data
Entry Printout or verbally by telephone. Airport Surveillance Radar (ASR) weather
information used by the Terminal Radar Approach Control (TRACON) controller is
primarily unprocessed @'broadband" radar. This is presented on an Automated Radar
Terminal System (ARTS) display or, at some airports, on a nonautomated ASR dis-
play. Remaining capabilities for the collection of weather information are largely
facility dependent with no automated retrieval capability for the controller. In
the current system, PIREP's, an important source of information aloft, are received
and relayed by controllers over control frequencies. Intra/interfacility communi-
cations of PIREP's are, for the most part, manual.

    b. <u>Planned Capabilities</u>. As part of the NAS Plan, the Central Weather Pro-
cessor Program was established in December 1981. The objective of this program is
to support the management, synthesis, and dissemination of accurate and timely
weather information to controllers, pilots, flight service specialists, and the
CWSU meteorologists. The CWP will acquire data from various weather sensors and
sources appropriate for the ARTCC/ACF area. It will process, store, and allow
meteorologist interaction with all graphic and alphanumeric products and will also
support automated distribution of products including distribution to the ARTCC/ACF.
The responsibilities of the meteorologist and weather coordinator are not expected
to change significantly from those at present (paragraphs 5a(1) and (2)); however,
their effectiveness and productivity should greatly increase. The meteorologist
interface with the CWP will be through the CWP work station: a physically sepa-
rate, but integral part of the CWP. Meteorologists at the CFWSU monitor weather
conditions to advise flow controllers in the TMF on conditions which might affect
the flow of traffic between major terminals. Automated support to the CFWSU mete-
orologist at the TMF will be provided by the Central Flow Weather Processor (CFWP),
a processor similar to the CWP at the ARTCC/ACF.

(1)   CWP Data Processing. The various data acquired by the CWP will require further processing to create and display the operationally oriented products required by the various NAS users. Processing and display capabilities shall include:

(a) Mosaicking, conpositing, and coordinating conversion to ARTCC/ACF coordinates of graphic weather radar data.

(b) Maintaining a current nonredundant PIREP data base.

(c) Maintaining current surface observation data base from conventional and Automated Weather Observing System (AWOS) stations in the ARTCC/ACF area. The CWSU meteorologist shall be provided the capability to request local graphic products based on the surface observation reports (i.e., station model plots and contours).

(d) Maintaining a current data base of graphic and alphanumeric NMC products.

(e) Provding time-sequenced animation of each graphic product resident in the CWP data base upon command from the CWP work station. Speed of animation (frames/second) and length of animation (number of previous frames) shall be selectable up to a predetermined maximum for each graphic product.

(f) Overlaying specified products and the capability to add annotations to products at the CWP work station.

(g) Processing routines to generate alarms/alerts when meteorological conditions occur which warrant the meteorologist's attention.

(2) CWP Interfaces. The CWP is interface intensive. Data from many different systems are acquired and processed by the CWP. Certain processed products are then distributed to other systems for use. Some of these systems will exist at the time of CWP deployment with well-defined CWP interfaces, while others will be later in implementation and presently have less well-defined interfaces, The CWP will support interfaces with the following systems:

(a) Weather Radar Systems. Initially, depending on program schedules, the RRWDS digitizers interfaced with the existing weather radar network may supply weather radar data to the CWP. Eventually, these will be replaced by the Next Generation Weather' Radar (NEXRAD). NEXRAD will provide better detection and classification of weather phenomena. NEXRAD is a Doppler radar system providing preprocessed products in addition to precipitation intensity (e.g., turbulence, shear, echo tops) by virtue of its volume scan and on-site processor capability. The CWP will serve as the FAA's gateway for NEXRAD information to NAS users (e.g., pilots, controllers, flight service specialists, and CWSU meteorologists). Additionally, to supplement this en route weather radar network, the weather channel of the ASR-9 system, at selected terminals will supply six-level weather radar data to the CWP.

(b) Weather Communications Processor (WCP). The WCP will provide the communications oriented processing required to support the distribution of weather products to users of the NAS through the MODE S Data Link.

(c) <u>MODE S Data Link</u>.   One of the potential applications of the data link portion of the MODE S system will be to provide graphic weather information to pilots on a request/reply basis.   The ultimate source of the graphics information for up-link will be the **CWP**; however, specific responsibilities between **CWP** and **WCP** relative to tailoring the cockpit graphics products have not yet been determined. **Additionally,** the **CWP** will receive **PIREP's** down-linked by pilots on MODE S data link (via the **WCP**).

(d) <u>Automated Weather Observing System (AWOS)</u>.   The **AWOS,** to be installed at selected airports with a published instrument approach procedure, will provide the **CWP** with real-time airport surface weather observations in the **ARTCC/ACF** area via the **ADAS.**

(e) <u>**Geostationary**</u> Operational Environmental Satellite (GOES). Each **CWP** will employ an earth station for reception of GOES image data via satellite. Visible and infrared image data will be processed for manipulation and displayed at the meteorologist work station.

(f) <u>Flight Service Automation System (FSAS)</u>. The **FSAS,** comprised of Automated Flight Service Stations **(AFSS)** and served by associated Flight Service Data Processing System **(FSDPS)** computers in each **ARTCC/ACF,** will receive certain weather products from the **CWP** such as radar mosaics and **CWSU** generated products.

(g) <u>Weather Message Switching Center Replacement (WMSCR)</u>.   The **WMSCR** will serve as the communications gateway between the various FAA **weather systems,** including the **CWP,** and the systems operated by the **NWS.**   This system will assure proper routing and communications of both graphic and alphanumeric **products** to **all** users.

(h) <u>Advanced Automation System (AAS)</u>. The **CWP** interface with the **AAS** will provide graphic and alphanumeric weather information for the controller. The **AAS** will maintain its own graphic and alphanumeric weather data base and will service individual controller's request for weather data.   Additionally, **PIREP's** received by controllers and entered at the sector suite will be provided to the **CWP** via the **AAS.**

(i) <u>Central Flow Weather Processor (CFWP)</u>. The **CFWP** in the **TMF,** a processor similar to the **CWP** in the **ARTCC/ACF,** will maintain and generate weather products to support national level management and monitoring of air traffic flow. The **CWP's** at each **ARTCC/ACF** will interface with the **CFWP** at the **TMF** to provide **CWP** weather products to the **CFWP.**

(j) <u>Maintenance Processor Subsystem (MPS)</u>. The **MPS** serves as the focal point for maintenance monitoring of the **ARTCC/ACF** and its associated remote equipment.   The **CWP** will interface with the **MPS** to provide status information.

c. <u>Future Expandability</u>.   The **CWP** must possess the capacity to interface with and process data from new sensors which are currently in a research or definition stage and are not presently **NAS** programs.   Examples of sensing systems

In this case (or may in) the future, may supply data to the CWP are: the Terminal Doppler Weather Radar System (TDWR) for improved detection of low-level wind shear in the airport area and atmospheric profiling and sounding systems for improved real-time information on winds and temperatures aloft.

6. ASSESSMENT.

a. Short-falls in Existing Capability. Currently, the CWSU meteorologist receives outputs of single weather radars (nonmosaicked) on dedicated displays, satellite imagery and NWS weather charts via facsimile (hard copy), and routine alphanumeric data from the Leased Service A. System. Collation and analysis of these data are required to generate nowcasts, forecasts, and advisories. Distribution of CWSU products to ARTCC controllers, TRACON, Tower, and Flight Service facilities is largely manual resulting in somewhat delayed dissemination to these users. Radar controllers (terminal and en route) receive radar weather information on the control display, but, due to the design of the radar systems for detection of aircraft, depictions of hazardous weather are limited. Controllers also have access to real-time information on in-flight conditions through PIREP's received from pilots on the sector control frequency. However, no convenient method exists for controllers to share this information with other controllers or the CWSU meteorologist. Effective acquisition and communication of PIREP's would result in more accurate CWSU generated products and more complete knowledge of real-time weather conditions by pilots and controllers.

b. Technological Opportunity. The opportunity exists to meet the mission need by virtue of the technology applicable to the CWP as well as the technology available in the interfacing systems. The state of hardware technology relative to the CWP is such that all requirements for data processing, storage, interactive graphics, and data communications can be met by integration of proven off-the-shelf equipment. Technology utilized in related NAS programs will also benefit and utilize the CWP capabilities. Doppler processing technology employed in NEXRAD will provide more products tailored to operational needs for weather information not presently available. Sensor technology employed in AWOS provides surface observations of most parameters measured today manually but will provide these observations at much higher rates. The MODE S data link network will provide the data communications path to up-link weather products in response to specific pilot requests and allow pilots to down-link PIREP's. The data switching and transmission requirements of the CWP will be met by the National Data Interchange Network (NADIN) and NAS Interfacility Communications System (NICS), respectively. The NADIN system will provide modular expandability to meet future data communications requirements and alternate routing capability to preclude data communication loss due to failed segments of the network. Requirements for nonswitched high volume data transfer will be met in most cases by dedicated circuits on the radio communications link network. In addition, the CWP program has benefited and continues to benefit from research and operational experiences which have demonstrated and validated meteorological functions and capabilities appropriate to the CWP. Of particular relevance is the National Oceanic and Atmospheric Administration's Program for Regional Observing and Forecasting Services which focuses on the application of automation to mesoscale area meteorological analysis and forecasting.

7. MAXIMUM COST MINIMUM BENEFIT.

    a. General Cost/Benefit. Life-cycle costs for CWP have been estimated at about $140 million. This was obtained by converting program year dollars to constant 1984 dollars, and these figures were then discounted to a 1984 present value in accordance with the Office of Management and Budget guidelines. Allocating quantitative benefits to CWP would require a comprehensive benefit/cost analysis for the entire NAS weather system and some method for allocating those benefits to the various components of that system. Since this has not yet been done, minimum life-cycle benefits and maximum life-cycle costs acceptable for meeting the mission need, have not yet been determined. However, the 1984 present value of benefits to the NAS from NEXRAD and its associated systems (e.g., CWP) have been estimated and these are $1,100 million.[1] This greatly exceeds the combined life-cycle costs of NEXRAD and CWP to the NAS, which are less than $300 million. (FAA will pay for approximately one-third of NEXRAD which has a life-cycle cost of nearly $446 million in 1984 dollars.) Additional CWP benefits will come from supporting other elements of the NAS weather system and from providing near real-time weather analysis products to controllers and pilots for the first time in NAS history. Accordingly, the CWP is seen to be highly cost-beneficial. This conclusion is also supported by another point of view. The annual cost of weather-related accidents and delays in the NAS was estimated to be approximately $800 million in 1981, which is $960 million in today's (1984) dollars.[2] CWP would operate from 1990 to at least 2005. If weather-related costs continued at -the $960 million level over that time period, then the present value of all those costs (discounted to 1984) is $4,500 million. Only 3.1 percent of these losses would provide benefits which are equivalent to the $140 million CWP life-cycle costs.

    b. Specific User Benefits. Benefits to the various users of weather data processed by the CWP are as follows:

        (1) Controllers. As a result of CWP, air traffic controllers and traffic management specialists will be more effective in minimizing the impacts of hazardous weather on air traffic. Tactical and strategic handling of traffic flows will improve as a result of improved nowcasts and, forecasts. Real-time depictions of severe and hazardous weather, processed by the CWP, will be available to controllers at the sector suite. This will greatly enhance the weather avoidance service provided to the pilot. Finally, manual handling of weather products by the controller will be eliminated reducing controller workload.

        (2) Flight Service Specialists. The CWP will enable the specialist to better serve pilots obtaining preflight and in-flight weather information. The CWP will provide the FSAS with mosaicked NEXRAD products as well as advisories and products generated by the CWSU meteorologists.

        (3) Pilots. Benefits to pilots will be realized indirectly through the improved weather-related services supplied by controllers and specialists. A more

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[1] "A Report on NEXRAD: National Airspace System Cost/Benefit," Report No. FCM-RG-1983, June 1983, U.S. Department of Commerce.

[2] "A Report on NEXRAD: National Airspace System Cost/Benefit," Report No. FCM-RG-1983, June 1983, U.S. Department of Commerce.

direct benefit to pilots will be evident with MODE S data link transactions. The
CWP will generate graphic products supplied to pilots in the cockpit. Addition-
ally, pilots will be able to directly enter PIREP's for processing by the CWP.

8. APPROACH ALTERNATIVES.

     a. Continuation of Present Approach. Continuation of the present approach
(manual CWSU/CFWSU) would result in the minimum capital costs to the FAA. However,
this system, as pointed out previously, is less efficient in terms of getting
operationally meaningful weather data to the various users than an automated
system would be. Its continued use would add to the economic losses imposed by
weather-related delays, cancellations, and diversions and in the general dissat-
isfaction with the services being provided as voiced by the different user groups.
Also, without CWP, full advantage of certain future NAS systems cannot be realized,
Sensor systems such as NEXRAD, ASR-9, GOES, and AWOS will have no central coherent
system for analysis and. creation of user products. Likewise, the systems that use
weather data (e.g., AAS, FSAS, MODE S data link) will have no consistent integrated
source for the weather products they require. Furthermore, while other areas of
the NAS evolve providing a higher ATC system capacity, maintaining the present
CWSU/CFWSU capabilities would lessen the impact of these capacity improvements by
limiting system efficiency during periods of adverse weather.

     b. Proposed CWP Approach. Implementation of the proposed CWP will greatly
improve the agency's capability to satisfy its mandate to provide safe and effi-
cient use of the Nation's airspace. This will occur through improved strategic
flow planning as a result of better forecasts and nowcasts and through better real-
time weather avoidance assistance to pilots ultimately resulting in:

          (1) A decrease in weather-related accidents.

          (2) An increase in operating efficiency by airspace users.

          (3) An increase in user confidence both within and external to FAA.

     c. Non-Technical Approaches. Non-technical approaches to meeting the
mission need do not exist. Approaches, such as changes in procedures and
regulations restricting flight near areas of known or forecasted hazardous
weather, will likely improve safety, but would render an already overloaded ATC
system virtually incapable of moving traffic during periods of hazardous weather
with these artificial constraints in place.

9. REFERENCES.

     a. Federal Aviation Administration, Aviation Weather System Plan, 1984.

     b. Federal Aviation Administration, National Airspace System Level 1 Design,
Document Baseline, NAS-DD-1000, October 1984.

     c. Jet Propulsion Laboratory, CWP Functional Requirements Version 2, March
1984.

     d. Federal Aviation Administration, Central Weather Processor Program Key
Decision Memorandum, August 1984.

e. Federal Aviation Administration, <u>Specification for Advanced Automation System</u>, **FAA-ER-130-005D,** April **1983.**

f. Federal Aviation Administration, Order **7210.38A,** <u>Center Weather Service Unit (CWSU),</u> April **1984.**

g. Jet Propulsion Laboratory, <u>Central Weather Processor Life-Cycle Cost Analysis</u>, April **1984.**

h. Jet Propulsion Laboratory, <u>User Requirements Interpretation: Central Weather Processor</u>, March **1985.**

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